REMARKS/ ARGUMENTS

The Office Action of November 4, 2004 has been carefully reviewed and this response addresses the Examiner's concerns.

Status of the Claims

Claims 1-11 were pending in the application.

Claim 11 was withdrawn.

Claims 1, 2, 5 and 7-10 are amended in order to more clearly express the invention.

Claim 7 was objected to because of apparent informalities.

Claims 2, 5, 7, 9 and 10 were rejected under 35 USC 112, second paragraph as being indefinite.

Claims 1-4 and 8 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent 6,563,974 to Agha Riza.

Claim 6 was rejected under 35 U.S.C. §103(a) as being unpatentable over Agha Riza in view of Domash et al. (U.S. Patent 6,587,573).

The 35 U.S.C. §112 rejection and the claim 7 objection

Claims 2, 5, 7, 9 and 10 were rejected under 35 USC 112, second paragraph as being indefinite.

The amended claims 1, 2, 5 and 7-10, rewritten in order to more clearly express the invention, overcome the 35 USC 112 rejections and the claim 7 objection.

Claim 1 is amended, adding the following statements:

said at least one switchable diffraction grating constituting a set of switchable diffraction gratings" and "said at least one final output beam constituting a set of output beams." The statement provides a basis for utilizing said at least one switchable diffraction grating as meaning one or more diffraction gratings and said at least one final output beam as meaning one or more output beam so that dependent claims can include two gratings or two output beams. Applicants would like to express their gratitude to Examiner Chiem whose comments the Applicants have attempted to incorporate in this amendment. While Applicants assert that the use of "at least one" as "one or more" can find a basis in *In re*

Gaubert, 524 F.2d 1222, 1227 (C.C.P.A. 1975), the amended claim results in a clearer language.

The 35 U.S.C. §102 rejection

Claims 1-4 and 8 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent 6,563,974 to Agha Riza.

Applicants respectfully request the Examiner reconsider the rejection of claims 1-4 and 8 based upon the amendments set forth above and the remarks set forth herein and below.

In order to clearly point out the novelty (and, incidentally, nonobviousness) of the present invention, Applicants present the basis for such novelty in two parts, the first being a summary of the Applicants' claimed invention and a general comparison of the relied upon Agha Riza patent with the present invention; and the second dealing with a specific comparison between the teachings of the Agha Riza patent and the elements of the presently claimed invention, more specifically, as presented by exemplary independent claims 1-4 and 8.

In the Applicants' claimed invention, an optical switch/variable attenuator includes a polarization separating subsystem that receives and input optical beam of arbitrary polarization and emits two optical beam of the same polarization, one or more switchable diffraction gratings receiving the two optical beams of the same polarization, and a polarization recombining subsystem that receives the receives the optical beams of the same polarization transmitted by the one or more switchable diffraction gratings and outputs one or more final output beams of combined polarization.

Agha Riza, in Fig. 5 of the '974 patent, teaches an optical switch/variable attenuator including a polarization beam displacing prism (BDP), two polarization sensitive devices, such as electrically controlled 90 degree linear polarization rotation devices such as liquid crystal devices, a polarizer disposed between the two polarization sensitive devices, where the polarizer is used for attenuating light between the two stages of the polarization processing, and another polarization beam displacing prism (BDP). A

BDP takes as input one unpolarized beam and outputs two parallel, laterally displaced, orthogonally polarized beams (see the description of two commercially available BDPs given in Appendix I). Liquid crystals are birefringent materials that have different transmission properties for different polarizations (see, for example, PLC Virtual Textbook at http://plc.cwru.edu/tutorial/enhanced/files/textbook.htm, reproduced in Appendix II).

Comparing claim 1 of the Applicants' claimed invention to the system disclosed in Fig. 5 of the '974 patent, the Applicants' claim a system including a polarization separating sub-system capable of emitting a first emitted optical beam of the first polarization and a second emitted optical beam of the first polarization, such as that described in U.S. Patent application Ser. No. 10/668,975, assigned to the same assignee as in the present application, while BDP1 of Fig. 5 of the '974 patent emits two parallel, laterally displaced, orthogonally polarized beams and does not emit two optical beams of the same polarization. Furthermore, the system in claim 1 of the Applicants' invention includes a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, while the BDP2 of Fig. 5 of the '974 patent combines two parallel, laterally displaced, orthogonally polarized beams into one beam of combined polarization (compare the polarization splitter 140 and the polarization combiner 170 of Fig. 4 of U.S. Patent application Ser. No. 10/668,975, which is incorporated by reference in the Applicants' specification and provided in Appendix III, to the BDPs shown in Appendix I). Since the '974 patent does not teach <u>a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization</u>, or <u>a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization</u>, Applicants respectfully assert that the '974 patent (Agha Riza) does not disclose, expressly or inherently, at least one patentable limitation (element) of claim 1.

Comparing claim 2 of the Applicants' claimed invention to the system disclosed in Fig. 5 of the '974 patent, the Applicants' claim the system of claim 1 further including a static grating optically disposed between the at least one switchable diffraction grating and the polarization recombining sub-system, while the system of Fig. 5 of the '974 patent includes a BDP, a spatially multiplexed processing (SMP) macro-pixel device (a liquid crystal device in the embodiment shown in Fig. 5), a polarizer, another SMP device and another BDP. A polarizer is "an optical device capable of transforming unpolarized or natural light into polarized light, usually by selective transmission of polarized rays," according to the definition in The Photonics Dictionary (available at http://www.photonics.com/dictionary/lookup/XQ/ASP/url.lookup/entrynum.4134/letter.p/pu./QX/lookup.htm, which is reproduced in Appendix IV). A grating is an array of diffracting elements (see, for example, Hetch, Optics, ISBN 0-201-11609-X, p. 424, which is attached in Appendix V). Thus, the system of Fig. 5 of the '974 patent does not include a static grating. Since the system of Fig. 5 of the '974 patent does not include <u>a static grating optically disposed between the at least one switchable diffraction grating and the polarization recombining sub-system</u>, Applicants respectfully assert that the '974 patent (Agha Riza) does not disclose, expressly or inherently, at least one patentable limitation (element) of claim 2.

Similarly, in claim 4 of the Applicants' claimed invention, the Applicants' claim the system of claim 1 further including a static grating optically disposed between the polarization separating sub-system and the at least one switchable diffraction grating. By the arguments presented above, since the system of Fig. 5 of the '974 patent does not include <u>a static grating optically disposed between the polarization separating sub-system and the at least one switchable diffraction grating</u>, Applicants respectfully assert that the '974 patent (Agha Riza) does not disclose, expressly or inherently, at least one patentable limitation (element) of claim 4.

Regarding amended claim 8, the provided optical system in the Applicants' claimed invention includes at least one switchable volume diffraction grating <u>and a static grating.</u>

By the arguments presented above, since the system of Fig. 5 of the '974 patent does not include a static grating, Applicants respectfully assert that the '974 patent (Agha Riza) does not disclose, expressly or inherently, at least one patentable limitation (element) of claim 8.

To anticipate a claim a reference must teach every element of the claim. (MPEP §2131). "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). As described, Agha Riza does not disclose, expressly or inherently, a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a static grating, and, thus, Agha Riza (the '974 patent) does not anticipate the Applicants' claimed invention of claims 1-4 and 8.

Applicants respectfully assert that amended independent Claims 1, 8 are not anticipated by Agha Riza (the '974 patent) and neither are any of the dependent claims. In addition, in view of the specific needs of Agha Riza (the '974 patent) (as discussed above) and since Agha Riza (the '974 patent) is lacking at least one patentable feature present in Claims 1, 8, and the dependent claims of the Applicants' invention, a modification of Agha Riza (the '974 patent) under 35 U.S.C. §103 would also be inapplicable because such modifications are not taught by nor obvious under Agha Riza (the '974 patent), and if incorporated into Agha Riza (the '974 patent), would render Agha Riza (the '974 patent) unsuitable for its intended functions.

The 35 U.S.C. §103 rejection

Claim 6 was rejected under 35 U.S.C. §103(a) as being unpatentable over Agha Riza in view of Domash et al. (U.S. Patent 6,587,573).

As stated above, Agha Riza does not disclose, expressly or inherently, a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a static grating. Domash et al. do not disclose, expressly or inherently, a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a static grating. Therefore combining Agha Riza with Domash et al. cannot be used to establish nor disclose, expressly or inherently, a system including a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a polarization recombining sub-system capable of capable of recombining the first transmitted optical beam of the first polarization and the second transmitted optical beam of the first polarization into at least one final output beam of combined polarization, or a static grating.

Under a 103 rejection, a prima facie case of obviousness of the invention is made in view of the scope and content of the prior art. In order to establish a *prima facie* case of obviousness, "there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references) must teach or suggest all of the claim limitations." MPEP §2143.

Neither Agha Riza nor Domash et al. separately or in combination teach all the patentable features of claim 6. In light thereof, Applicants respectfully traverse the 35 U.S.C. 103 rejection of the claim.

In conclusion, in view of the above remarks, Applicants respectfully request the Examiner find claims, 1-4, 6 and 8 as amended, as well as the other dependent claims, 5, 7, 9 and 10, allowable over the prior art and pass this case to issue.

Since the total number of claims is less than the number of claims already been paid for, no additional fees are required. However, if fees are required, they should be charged to Deposit Account No. 50-1078.

In accordance with Section 714.01 of the MPEP, the following information is presented in the event that a call may be deemed desirable by the Examiner:

JACOB N. ERLICH (617) 854-4000

Respectfully submitted,
Thomas W. Stone et al., Applicants

Dated: February 4, 2005

By: ______________________
Jacob N. Erlich
Reg. No. 24,338
Attorney for Applicants

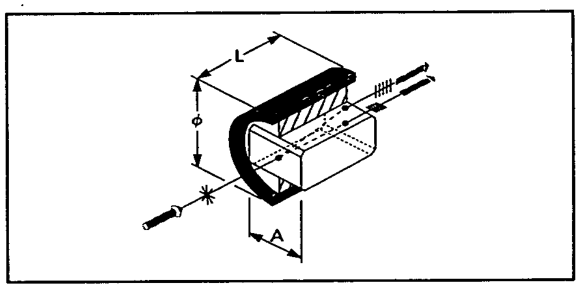
APPENDIX I

Available in:
✔ Production Quantities

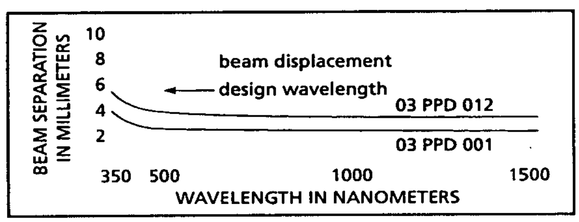
Beam-Displacing Prisms

Two parallel, but laterally displaced, orthogonally polarized output beams are transmitted from one unpolarized input beam when passing through a Melles Griot beam-displacing prism. If the input beam is linearly polarized, the output can be made to vary continuously and sinusoidally from one parallel beam to the other by rotating the input polarization angle.

- The ordinary beam is undeviated.
- The extraordinary beam is deviated by 6 degrees within the prism.
- Upon exit, the extraordinary beam is again parallel with the input beam and the exiting ordinary beam.
- Single-layer antireflection coatings are available centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.



03 PPD beam displacing prisms



Beam displacement

SPECIFICATIONS: BEAM-DISPLACING PRISMS

Wavelength Range: 350 nm to 2300 nm
Nominal Design Wavelength: 500 nm
Material: Optical and low-scatter-grade calcite
Transmission (Ratio of Total Output to Total Unpolarized Input): $(k_1+k_2) = 84\%$
Extinction Ratio (H_{90}): $<1 \times 10^{-5}$
Dimensional Tolerances: ±0.25 mm
Centration: 10 arc minutes
Surface Quality: 80–50 scratch and dig
Mounting:
Cylindrical black anodized aluminum housing; product number and line indicating plane of beam separation engraved on side of housing

Single-Layer MgF_2 Antireflection Coatings

Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

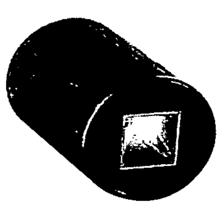
Parts with the /C coating may have slightly reduced transmission below 420 nm. Call for availability.

Beam Displacing Prisms

Grade	Outside Diameter ϕ (mm)	Housing Length L (mm)	Beam Displacement at 500 nm (mm)	Clear Aperture A (mm)	PRODUCT NUMBER
Optical Grade	25.0	26.0	2.7	10×10	03 PPD 001
	25.0	38.0	4.0	10×10	03 PPD 012
Low-Scatter Grade	25.0	26.0	2.7	10×10	03 PPD 301
	25.0	38.0	4.0	10×10	03 PPD 312

Note: For antireflection coated prisms please append coating suffix from coatings table above.
Polarizer holders can be found in Chapter 24, Lens, Filter, and Polarizer Mounts.

beam displacing prisms

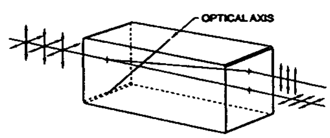


Beam displacing prisms are used to separate an input beam into two orthogonally polarized output beams. Both outputs are parallel with the input beam to within 30 arc-seconds.

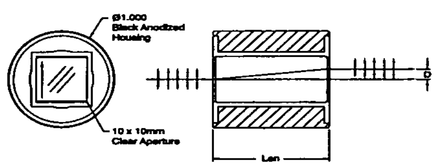
Our beam displacers use the highest quality optical grade calcite to achieve an operating range from 350 to 2300 nm.

Two versions are offered with displacements of 2.7mm and 4.0mm. The prisms are protected in a rugged anodized aluminum housing.

- 2 Orthogonally Polarized Outputs
- 2.7 and 4.0mm displacements
- Outputs Parallel with Input
- High Extinction Ratio – 100,000:1
- 350 to 2300nm Operation
- Highest Grade Optical Calcite
- 1" Diameter Housing



SPECIFICATIONS	
Material:	High Optical Grade Calcite
Extinction Ratio:	>100,000:1
Spectral Range:	350 to 2300nm
Beam Separation (@ 500nm):	
BD27:	2.7mm
BD40:	4.0mm
Clear Aperture:	10mm x 10mm
Beam Deviation:	<30 arc-sec
Wavefront Distortion:	<λ/4
Surface Quality:	40-20 Scratch Dig



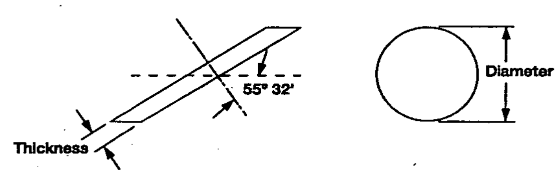
ITEM#	$	£	€	¥	"D"	"LEN"	DESCRIPTION
BD27	$460.00	£418.60	€506,00	¥78,200	2.7mm	1.10"	Beam Displacer, 2.7mm
BD40	$560.00	£509.60	€616,00	¥95,200	4.0mm	1.60"	Beam Displacer, 4.0mm

brewster windows

Brewster Windows are uncoated substrates which are used at Brewster's Angle (the angle at which p-polarized light suffers no reflection loss). Brewster's Angle is calculated from:

$$B = \tan^{-1}(n)$$

where B is Brewster's Angle and n is the index of refraction of the material. At this angle p-polarization reflectance drops to zero. When used in a laser cavity, a Brewster Window causes the laser output to be polarized:



- Transmitted Wavefront: λ/20
- Wedge ≤ 5 Arc Seconds
- Zero Reflection Loss for P-Polarized Light

SPECIFICATIONS	
Material:	Fused Silica
Parallelism:	≤5 Arc Sec.
Thickness Tolerance:	±0.1mm
Surface Quality:	10-5 Scratch Dig
Transmitted Wavelength:	λ/20
Brewster Angle:	55° 32'
Minor Axis Tolerance:	+0.00/–0.13mm

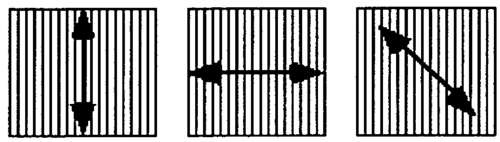
ITEM#	MINOR DIAMETER	THICKNESS	$	£	€	¥
BW0601	6.0mm	1.0mm	$70.00	£63.70	€77,00	¥11,900
BW0801	8.0mm	1.0mm	$90.00	£81.90	€99,00	¥15,300
BW0802	8.0mm	2.0mm	$110.00	£100.10	€121,00	¥18,700
BW0902	9.0mm	2.0mm	$112.00	£101.92	€123,20	¥19,040
BW1302	13.0mm	2.0mm	$140.00	£127.40	€154,00	¥23,800

APPENDIX II

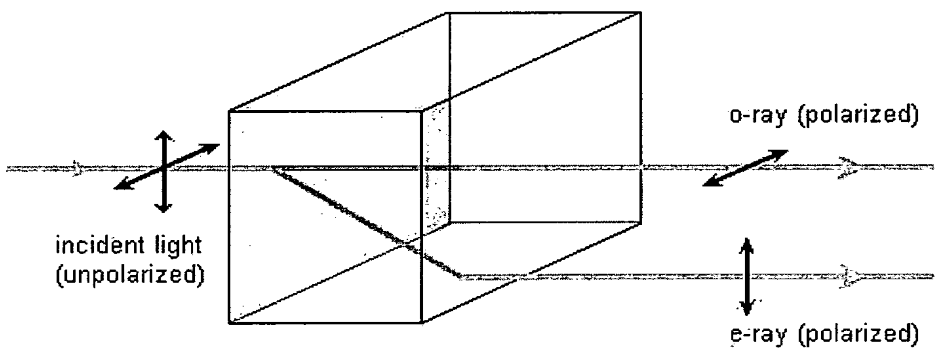
Birefringence in Liquid Crystals

The previous section introduced the concepts of polarized light and *polarizers*. This section will show how these ideas are important to liquid crystals.

Liquid crystals are found to be birefringent, due to their *anisotropic* nature. That is, they demonstrate double refraction (having two indices of refraction). Light polarized parallel to the director has a different index of refraction (that is to say it travels at a different velocity) than light polarized perpendicular to the director. In the following diagram, the blue lines represent the director field and the arrows show the polarization vector.



Thus, when light enters a birefringent material, such as a nematic liquid crystal sample, the process is modeled in terms of the light being broken up into the fast (called the ordinary ray) and slow (called the extraordinary ray) components. Because the two components travel at different velocities, the waves get out of phase. When the rays are recombined as they exit the birefringent material, the polarization state has changed because of this phase difference.



Light traveling through a birefringent medium will take one of two paths depending on its polarization.

The birefringence of a material is characterized by the difference, Δn, in the indices of refraction for the ordinary and extraordinary rays. To be a little more quantitative, since the index of refraction of a material is defined as the ratio of the speed of light in a vacuum to that in the material, we have for this case, $n_e = c/V_{||}$ and $n_o = c/V_{\perp}$ for the velocities of a wave travelling perpendicular to the director and polarized parallel and perpendicular to the director, so that the maximum value for the birefringence, $\Delta n = n_e - n_o$. We won't deal here with the general case of a wave travelling in an arbitrary direction relative to the director in a liquid crystal sample, except to note that Δn varies from zero to the maximum value, depending on the direction of travel. The condition $n_e > n_o$ describes a positive uniaxial material, so that nematic liquid crystals are in this category. For typical nematic liquid crystals, n_o is approximately 1.5 and the maximum difference, Δn, may range between 0.05 and 0.5.

The length of the sample is another important parameter because the phase shift accumulates as long as the light propagates in the birefringent material. Any polarization state can be produced with the right combination of the birefringence and length parameters.

It is convenient here to introduce the concept of optical path in media since for the above two wave components travelling with different speeds in a birefringent material, the difference in optical paths will lead to a change in the polarization state of the wave as it progresses through the medium. We define the optical path for a wave travelling a distance L in a crystal as nL so that the optical path difference for the two wave components mentioned above will be $L\ (n_e - n_o) = L\Delta n$. The resultant phase difference between the two components (the amount by which the slow, extraordinary component lags behind the fast, ordinary one) is just $2\pi\ L\Delta n/\lambda v$ where λv is the wavelength in vacuum.

The following simulation demonstrates the optical properties of a birefringent material. A linearly polarized light wave enters a crystal whose extraordinary (slow) index of refraction can be controlled by the user. The length of the sample can also be varied, and the outgoing polarization state is shown. The concept of optical path difference and its influence on polarization state can also be explored here. This leads to a discussion of optical retardation plates or phase retarders, in the context of the simulation.

Application to Polarized Light Studies of Liquid Crystals

Consider the case where a liquid crystal sample is placed between crossed polarizers whose transmission axes are aligned at some angle between the fast and slow direction of the material. Because of the birefringent nature of the sample, the incoming linearly polarized light becomes elliptically polarized, as you have already found in the simulation. When this ray reaches the second polarizer, there is now a component that can pass through, and the region appears bright. For monochromatic light (single frequency), the magnitude of the phase difference is determined by the length and the birefringence of the material. If the sample is very thin, the ordinary and extraordinary components do not get very far out of phase. Likewise, if the sample is thick, the phase difference can be large. If the phase difference equals 360 degrees, the wave returns to its original polarization state and is blocked by the second polarizer. The size of the phase shift determines the intensity of the transmitted light.

If the transmission axis of the first polarizer is parallel to either the ordinary or extraordinary directions, the light is not broken up into components, and no change in the polarization state occurs. In this case, there is not a transmitted component and the region appears dark.

In a typical liquid crystal, the birefringence and length are not constant over the entire sample. This means that some areas appear light and others appear dark, as shown in the following microscope picture of a nematic liquid crystal, taken between crossed polarizers. The light and dark areas that denote regions of differing director orientation, birefringence, and length.

Image courtesy of E. Merck Company

The Schlieren texture, as this particular arrangement is known, is characteristic of the nematic phase. The dark regions that represent alignment parallel or perpendicular to the director are called brushes. The next section will describe the textures of liquid crystals in greater detail, but before going there lets see how birefringence can lead to multicolored images in the examination of liquid crystals under polarized white light.

Colors Arising From Polarized Light Studies

Up to this point, we have dealt only with monochromatic light is considering the optical properties of materials. In understanding the origin of the colors which are observed in the studies of liquid crystals placed between crossed linear polarizers, it will be helpful to return to the examples of retarding plates discussed in the Birefringence Simulation. They are designed for a specific wavelength and thus will produce the desired results for a relatively narrow band of wavelengths around that particular value. If, for example, a full-wave plate designed for wavelength is λ' is placed between crossed polarizers at some arbitrary orientation and the combination illuminated by white light, the wavelength λ' will not be affected by the retarder and so will be extinguished (absorbed) by the analyzer. However, all other wavelengths will experience some retardation and emerge from the full-wave plate in a variety of polarization states. The components of this light passed by the analyzer will then form the complementary color to λ'.

Color patterns observed in the polarizing microscope, together with the extinctions already noted in the connection with the Birefringence Simulations are very useful in the study of liquid crystals in many situations, including the identification of textures, of liquid crystal phases and the observations of phase changes.

The following simulation illustrates the role of birefringence in the formation of colored images by a liquid crystal sample located between crossed linear polarizers when observed, for example, in a microscope. The simulation allows you to adjust the birefringence, the length, and the orientation, θ, of the liquid crystal sample. Here, θ is the angle between the director and the vertical direction (The transmission direction of the polarizer).

Colors from Birefringence

Temperature Dependence of Birefringence

Recall that the birefringence of a material results from its anisotropy and the anisotropy of liquid crystals show a strong temperature dependence, vanishing at the nematic to isotropic phase transition. Hence, the birefringence shows a significant temperature dependence. This is discussed and illustrated in the following simulation.

Temperature Dependence of Birefringence

Light and Polarization

Textures and Defects

APPENDIX III

APPENDIX IV

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polarizer

See PREVIOUS | NEXT term in listing

Definition:

An optical device capable of transforming unpolarized or natural light into polarized light, usually by selective transmission of polarized rays.

Return to previous term listing
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A B C D E F G H I J K L M N

O P Q R S T U V W X Y Z

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APPENDIX V

maximum has a broad flat top; in other words, at the origin, which is the center of the peak, the second derivative of the irradiance function is zero; there is no change in slope (Fig. 10.40).

Unlike the Rayleigh rule, which rather tacitly assumes incoherence, the Sparrow condition can readily be generalized to coherent sources. In addition, astronomical studies of equal-brightness stars have shown that Sparrow's criterion is by far the more realistic.

10.2.7 The Diffraction Grating

A repetitive array of diffracting elements, either apertures or obstacles, that has the effect of producing periodic alterations in the phase, amplitude, or both of an emergent wave is said to be a **diffraction grating**. One of the simplest such arrangements is the multiple-slit configuration of Section 10.2.3. It seems to have been invented by the American astronomer David Rittenhouse in about 1785. Some years later Joseph von Fraunhofer independently rediscovered the principle and went on to make a number of important contributions to both the theory and technology of gratings. The earliest devices were indeed multiple-slit assemblies, usually consisting of a grid of fine wire or thread wound about and extending between two parallel screws, which served as spacers. A wavefront, in passing through such a system, is confronted by alternate opaque and transparent regions, so that it undergoes a modulation in *amplitude*. Accordingly, a multiple-slit configuration is said to be a ***transmission amplitude grating***. Another, more common form of transmission grating is made by ruling or scratching parallel notches into the surface of a flat, clear glass plate [Fig. 10.34(a)]. Each of the scratches serves as a source of scattered light, and together they form a regular array of parallel line sources. When the grating is totally transparent, so that there is negligible amplitude modulation, the regular variations in the optical thickness across the grating yield a modulation in *phase*, and we have what is known as a ***transmission phase grating*** (Fig. 10.35). In the Huygens–Fresnel representation you can envision the wavelets as radiated with different phases over the grating surface. An emerging wavefront therefore contains periodic variations in its shape rather than its amplitude. This in turn is equivalent to an angular distribution of constituent plane waves.

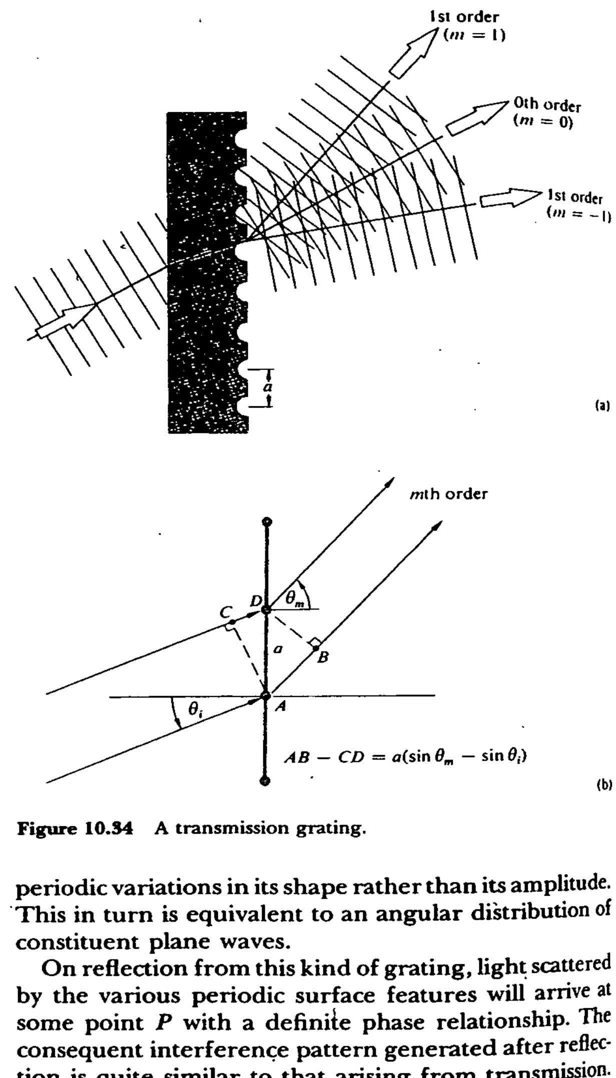

Figure 10.34 A transmission grating.

On reflection from this kind of grating, light scattered by the various periodic surface features will arrive at some point P with a definite phase relationship. The consequent interference pattern generated after reflection is quite similar to that arising from transmission. Gratings designed specifically to function in this fashion are known as ***reflection phase gratings*** (Fig. 10.36). Contemporary gratings of this sort are generally ruled in thin films of aluminum that have been evaporated onto optically flat glass blanks. The aluminum, being fairly